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28 March 1962

MEMORANDUM FOR: Chief, Technical Plans & Development Staff

SUBJECT: "Flight Recorders" for the OXCART Program

1. PROBLEM

a. The following flight parameters are necessary for mensuration accomplished on photography from any photo collection system.

- (1) Space position of exposure station: Latitude
Longitude
Altitude
- (2) Elements of orientation of camera: Pitch
Roll
Yaw (drift and heading)

In addition, relative time, Z time and vehicle velocity are required.

b. The above data are required for any mensuration and are available presently by several techniques.

(1) Assumptions and educated guesses are sometimes resorted to by necessity. For example, often work accomplished on photography has to be done with assumed values for pitch, roll and yaw because of the lack of any flight data or techniques for rapidly computing the required data. These assumed values are generally approximate and do not allow for high precision mensuration.

(2) Indirect methods are available for determining the required flight parameters. These include techniques such as space resection whereby ground control can be used to determine exposure stations in space, but this method is dependent upon some form of geometric or time correlation and these elements are in most cases lacking.

(3) The newest method of determining flight parameters has evolved from some of the latest advances in inertial navigation systems for missiles, rockets and polaris submarines, etc. These inertial navigation systems provide a new capability in determining space position and orientation, including time and velocity.

Control System

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2. ASSUMPTIONS

a. That missions will be accomplished for highest priority targets requiring technical intelligence and, therefore, high precision mensuration. It is believed that pioneer and first coverage reconnaissance missions will be at a minimum and that even in these missions, targets found will require technical intelligence exploitation requiring high precision in mensuration and rectification.

b. That some of the flight parameters can be determined by graphical or indirect methods but these methods generally cannot provide the degree of accuracy required for technical intelligence.

c. That the indicated methods for determining flight parameters are not sufficient in themselves because of the lack of good maps, ground control, etc., but are useful only as checks to the otherwise determined flight parameters.

d. That no other method is available to determine the required flight parameters other than the data from an inertial navigation system continuously recording the required outputs.

e. That providing the output of the inertial navigation system on magnetic tape is a better technique than providing the same data in a data chamber, because the magnetic tape provides a faster readout, allows for real-time computer operation and actual orientation of the Perkin-Elmer camera platform. (The P-E camera platform is gyro stabilized but actual orientation is unknown.) In addition, the present data chambers do not provide a complete recording of data required which is available in inertial navigation systems.

f. That a real-time computer system will be available at NPIC. The Remington Rand 490 system is scheduled for delivery in October.

g. That the OXCART aircraft can accommodate flight recorder units required to provide the necessary flight parameters. Space is available and the added weight can be justified by the requirement for flight recorders.

3. DISCUSSION

a. Inertial navigation systems have been developed on a crash basis to meet the needs of space age systems (missiles, rockets, aircraft, submarines, etc.) The concepts have been known and worked on for years but it remained for the impetus and financial backing of space age requirements to rush a development of equipment and the establishment of techniques to an operational state of

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readiness. Original work by Schuler in Germany in the 1920s was instrumental in the development of inertial systems. These inertial systems provide a technique for automatic navigation and, in addition to the space position, time reference, orientation of vehicle platform can be read out. Inertial systems will, in all probability, be carried on all future cartographic and reconnaissance systems. Great possibilities also exist for combination stellar-inertial systems for use in near earth orbital flights as well as space flights in general.

b. At the same time development has been progressing in inertial navigation systems, development has also been progressing in computers; for example, a small digital computer is an integral part of an inertial navigation system and another development area in computers is the development of real-time systems such as the one being developed for use in NPIC (the Remington Rand 490 real-time computer system). A flight recorder which produces flight parameters on magnetic tape and is, therefore, immediately available at the conclusion of the mission for readout will make possible a real-time computing system at NPIC. If some of the flight parameters were available in the data chamber, this information would not be available at NPIC until such time as the film was processed and a DP or DN was sent to NPIC. A delay would result in extracting flight parameters from the data chamber, punching cards and storing this data in the 490 computer. The magnetic tape from the flight recorder can be loaded into the computer directly and provides a capability of making highly accurate measurements during the OAK and MCI, in contrast to the current techniques of basing most of the requisite computer inputs on experience and assumptions. The flight recorder data would also provide a capability for automatic mission indexing. This photo indexing produced by a computer prior to the time that film is available at NPIC might possibly be better than the photo index producing by hand plotting because of the inaccuracies of maps currently available.

c. A big advantage of a flight recorder would be the speed in which the flight parameters can be stored in the computer. Present methods on KH call for a scribing operation on each horizon shot, subsequent mensuration of horizon images, computer reduction and electronic plotter output, etc. This is a very time consuming operation and the accuracies resulting from the horizon reduction procedures are not of a high order of accuracy. Other techniques shortly to be available for the determination of vehicle orientation are stellar techniques whereby a photographic exposure of a stellar field with known position and time provides sufficient data to compute very precise orientation of the vehicle, but this system again, though it produces very accurate results, is a very time consuming method.

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d. In addition to savings in time and improvement in accuracy, another savings effected by the incorporation of flight recorders in the OXCART program would be a savings in man power. The present TAB staff spends over 25 percent of their total effort in determining flight parameters required for mensuration. These are accomplished by graphic techniques, space resection techniques, horizon reduction techniques, etc., with less time available for actual mensuration. The flight recorder would provide a great savings in man power requirements.

e. Some of the flight parameters provided are available in no other way unless some form of ground control is available. For example, relative position between two exposure stations is required for "two photo space intersection" techniques which will be used with the OMI RIC/Is and computer. The air base that can be established from most maps available is useless, but the flight recorder would provide useful data.

f. The flight parameters of vehicle velocity, vehicle altitude, and the V/H signal have been discussed with the Computer Branch and TAB in some detail. These three parameters might possibly not be able to be provided in the accuracies stated in the Minneapolis-Honeywell proposal. It is believed that if such is the case, these data are still required because some ground control is always available and statistical smoothing techniques available with the new Remington Rand 490 computer system will provide a capability of upgrading the accuracies of these parameters.

g. The Eastman Kodak camera system requires a flight recorder unless changes are made in the system presently being fabricated.

4. CONCLUSIONS

A requirement exists for a flight recorder to be installed in each OXCART aircraft used for an operational mission. This flight recorder and associated readout equipment can be designed and fabricated by Minneapolis-Honeywell, who are the manufacturers of the inertial navigation system used in the aircraft.

5. ACTIONS RECOMMENDED

a. To accept the Minneapolis-Honeywell proposal of 12 January, as stated, and to transfer funds in the amount of \$222,837 to DFD immediately with the request that Phase I of the proposal be initiated and contracted for with Minneapolis-Honeywell. Phase I includes the following: design, customer liaison, fabrication, tests, reports, product liaison and includes two data recorders and two playback units. Total cost, \$206,331 plus \$16,560 and a total engineering cost of \$222,837.

Nc

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b. It is further recommended that Phase II of the proposal be kept open until such time as the exact number of flight recorders needed is determined; for example, if eight flight recorder units were required, the unit price for each recorder would be \$47,000. For ten units \$46,236 and for 12 units \$44,960.

c. It is recommended that the TDC approve this transfer of funds to DPD for the design, fabrication and incorporation of these flight recorders into the OXCART program. This new concept of flight recorders had not been planned for the DPD budget for the original funding and, therefore, it has been requested that NPIC, if a requirement for such equipment existed, would fund this development.

d. It is necessary that this action be taken as soon as possible if its incorporation in the first OXCART vehicle is to be insured. Discussions in depth have been held with Messrs. [redacted]

[redacted] of DPD regarding the development of inflight recorders. If NPIC recommends funding this development, continuous liaison between NPIC, DPD, Eastman Kodak, Perkin-Elmer and Minneapolis-Honeywell will be required.

NO.

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